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With Mr. Ellis's compts.

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OBSERVATIONS

ON THE

NATURAL HISTORY AND STRUCTURE

OF THE

PROTEUS ANGUINUS.

By Sig. CONFIGLIACHI and Dr RUSCONI.

THE *Proteus Anguinus* is an animal that has much excited the curiosity of zoologists, and many points in its natural history and anatomy still remain undecided. Of late this animal has been examined with far greater minuteness, and under much more favourable circumstances than heretofore, by two Italian naturalists of distinguished ability; and the results of their labours have been given to the world in a work, entitled, "*Del Proteo Anguino di Laurenti Monografia, publicata da Pietro Configliachi, Professore Ordinario di Fisica nella Imperiale Regia Universitá di Pavia, e da Mauro Rusconi, Dottore in Medicina e Publico Ripetitore di Fisiologia.*"—*Pavia*, 1819. This work is illustrated by excellent engravings, from most accurate drawings by Dr Rusconi himself; and as only a few copies of it have yet reached this country, perhaps an abridged account of the labours of these ingenious naturalists, which have so much contributed to clear up the doubts respecting this singular animal, may not be unacceptable to such as take an interest in such subjects, and have not the opportunity of consulting the original work.

It appears that the first knowledge of this animal was communicated to the public by Dr Laurenti, in his *Synopsis Reptilium*, about the year 1768. A fuller description of it was published by Dr Scopoli in 1772; and in the new edition of the *Systema Naturæ* of Linnæus, edited by Gmelin, notice is taken

of it. After this Hermann and Schreibers wrote on the Proteus, but described only its external parts, and contributed nothing to clear up the many doubts and conjectures respecting it. In this state of uncertainty, Dr Schreibers first had recourse to anatomy, as the only satisfactory mode of gaining correct information: but unfortunately he possessed only three Protei, which had been sent to him from Carniola, preserved in spirits; which circumstance precluded him from giving that complete information which might otherwise have been expected from so eminent a naturalist. His description was published in 1801; and among many excellent observations, he points out the striking differences of form in the lungs of the *Sirena lacertina*, compared with those of the *Proteus* *. Next to Schreibers, we have to notice two zoologists of the highest celebrity, MM. Cuvier and Rudolphi, both of whom examined the internal structure of this animal. The former first discovered, and accurately described the organs of generation in the female, and established, on a solid foundation, that the Proteus was not a *larva*, as many had supposed, but a *perfect animal*; an opinion now generally followed, and confirmed by the recent observations of Rudolphi, who has described the generative system in the male, and communicated observations on the globules of the blood, which, in this animal, seem to be of an unusually large size.

* The authors here observe in a note, that Dr Schreibers, aware of the imperfection of his former description, had lately resumed the subject, and applied himself not less to study the habits than the internal structure of the Proteus. Uninformed of his intentions, the authors had transmitted to him at Vienna a copy of their plates, with the accompanying explanations, and a request that he would favour them with his opinion of their labours, and his advice, where it might appear to him that they had been mistaken. With a liberality that does him great honour, he replied, "Since you have anticipated me, continue the work you have so well begun: when the work shall be published, I will cause a translation of it to be made into our language, under my own eyes, and as I have procured very many of these animals, with the view of instructing myself on various points, I shall be able to add to the translation not a few observations, and perhaps some plates." The authors observe, that they announce, with great satisfaction to zoologists, this intended translation of their work, and the additions it is destined to receive. The fame of Sig. Schreibers renders it unnecessary for them to say more; they add only, that he has devoted many years to this subject, and sacrificed more than 100 protei to his learned researches.

The Proteus Anguinus lives and multiplies in the water of certain subterranean caverns of Carniola. The province in which these caverns occur is divided by a chain of mountains of secondary or *transition* limestone, on which rest many hills of posterior formation. Both in the mountains and hills are many caverns and subterraneous passages stretching in various directions, and lying in different planes. These caverns communicate with one another, so that the water first collected in those at a higher level, falls down and circulates through subterraneous channels, till it settles in the lower caverns, some of which are of vast size and depth. Two of the most remarkable of these caverns are situate near Adelsberg, a village lying midway between Trieste and Lubiana. One of them, called the Cavern of Adelsberg, is close to the village, and the other, named the Cavern of Maddalena, is only a few miles distant. It is in this last that the peasants at present go to fish for Protei. On the 2d of August 1816, the authors, attended by three peasants, furnished with torches, and with a small net in the shape of a bag, fixed to the end of a staff, prepared to enter this cavern. At 5 o'clock A. M., the temperature of the external air at the mouth of the cavern was 48° Fahr*. As they descended, they passed through spacious apartments, some of them clothed with stalactites and calc-spar, which reflected with great brilliancy the light of the torches, and exhibited a magnificent appearance. Others appeared like pits of mud, which rendered the walking very inconvenient. At length they reached a stagnant pond, about 30 feet broad, and at a depth below the surface of about 170 toises. In this pond they saw one proteus, but did not succeed in taking him; and from the water being turbid, and in too great quantity, in consequence of heavy rains the day before, they were obliged to reascend, after having been two hours in the cavern, without taking a single proteus. The temperature of the water in this pond was 55°, and that of the air of the cavern was stationary at

* In the original, the temperatures are given according to the scale of Reaumur, which are here converted into the corresponding degrees of Fahrenheit. As great precision is not necessary, the nearest *whole* numbers of Fahrenheit are taken, in order to avoid fractions.

54°.5, while the thermometer, left in free air at the mouth of the cavern, had risen from 48° to 59°. The specific gravity of the water in the pond was to that of distilled water, at the same temperature, as 101°.5 to 100°. These animals are found in other pits of stagnant water in Carniola and elsewhere. The first protei described by Laurenti and Scopoli were not procured from the Lake of Zirknitz, as has been commonly represented, nor from any of the caverns of Carniola, but were found accidentally by the peasants in small puddles of water near the mouths of certain caverns, a little distant from Sittich, on the road to Newstadt, in Lower Carniola, cast out of the caverns probably by the overflowing of their water after heavy rains. It was not till the year 1797, that these animals were discovered in the caverns of Maddalena. At present, the peasants of Adelsberg, when the season suits, go to fish for them, and preserve them alive, till they sell them to the curious who visit Carniola, or convey them to Trieste, where they are sold for the small sum of two or three *lire* each.

Regarding the form and habits of the proteus, the authors observe they shall be brief. As to external *form*, the accompanying figure, (see Plate,) drawn with all possible care and attention, will much more clearly make it known than any words can do; and on this point, therefore, they profess to note down only such things as could not be exhibited by a figure, or which the draughtsman could but imperfectly represent. With regard to *habits*,—to describe these with minuteness and perfect accuracy, it would be necessary to observe the animal in its native caverns, and not in the state of captivity in which it has been seen by them. They will faithfully state, however, all they have observed of these animals, while kept in vessels within doors for more than two years: and from the observations thus made, and from comparisons between the proteus and aquatic salamander, will deliver the best judgment they have formed of their habits and way of life.

The authors are not able to speak positively either of the age or of the size at which these animals arrive. None of the protei seen by them exceeded 12 inches in length, and the smallest they have heard of was only four *: It was seen by Dr Pockels,

a skilful anatomist, and not less estimable for his learning than for the suavity of his manners. There is reason to believe, that, when at their full growth, they reach to 14 inches or even more. That described by Schreibers in 1801 was 13 inches in length. With regard to age, there is reason to think they are pretty long lived; for the Archduke John of Austria, a zealous cultivator and liberal patron of natural science, kept, in a subterranean grotto, constructed for the purpose, several of these animals, one of which lived eight years, and acquired a size greater than ordinary.

When viewed alive, and in water, the body of the proteus appears at first of a cylindrical form, but when more attentively surveyed, it is seen to be somewhat flattened on the sides, especially towards the tail, which, beyond the lower limbs, is reduced at length to the shape of a spatula. The back and head of the animal are of a whitish-red colour, which, on the sides and tail, inclines to violet. The belly, on the contrary, is white, though even there, in the region of the liver, it has a bluish cast, like that of the human veins, seen through a very fine and delicate skin. An illustrious writer, who had observed a proteus only after having been kept in spirits, has described the skin as very opaque; but we, say the authors, who have seen many protei alive, can with confidence affirm, that so far from being opaque, the skin of these animals is, almost beyond belief, transparent,—to such a degree, indeed, that the colours or tints, as painters express it, are so very diaphanous, that, to represent it by words, is quite impossible, and by the pencil sufficiently difficult. Those unacquainted with painting may doubt our assertion, but those the least instructed in that art, and who know by experience how difficult it is to imitate a diaphanous tint, will remain painfully convinced of this, when told that the diaphanity of the tints of the *Proteus Anguinus* (be the human skin as white, morbid, and subtile as you please) exceeds by far that of the colours of the human body. But the flesh-colour of this animal in course of time changes; and this happens more or less quickly, according as he is more or less exposed to the light. From whitish-red the skin passes by

* The authors employ the old French measures.

degrees to violet; so that to preserve the natural colour, it is necessary to keep the animal always in obscurity.

The skin of this reptile, like that of eels, is every where besmeared with a viscid mucus; and when viewed with a lens, it is observed to be studded with minute reddish spots, and with innumerable pores. By reason of this mucosity, the proteus easily slides out of the hand, and while alive, is with difficulty fixed down to any substance for the purpose of dissection. In attempts to do this, say the authors, we have destroyed many protei, and have observed, that, when about to die, the body has become covered with so much mucus, that it appeared difficult to believe how they were able to afford it.

In enumerating the external organs, the authors pass over for the present the eyes and gills, till they come to describe anatomically the organs of sense and of circulation. As to the mouth, it differs from that of other reptiles. The superior lip, after covering the teeth, is continued a little downward over the inferior one in front; and, on the other hand, the inferior lip is continued upward over the superior one on the sides of the mouth. The size of the head and tail is, in some protei, larger in proportion to the body than in others, depending probably on the relative age of the animal, and not on particular seasons, as is the case in the aquatic salamander.

When a proteus that has been kept some time in darkness is observed with caution, he is always found to be resting quietly at the bottom of the vessel, and in the position nearly represented in the figure. But if the vessel be quickly uncovered, he suddenly begins to move, is much agitated, and seeks always that part of the vessel which is darkest. If now that part of the vessel be exposed to the light, the animal again begins to move, and soon his gills assume a redder tint, and the rest of the body also becomes of a redder hue. In fact, the light gives pain, and the animal exerts himself to avoid it. This disposition to escape from light is the more remarkable, as the eyes of this animal are incredibly small, and so buried beneath the skin, that a person even apprized of their situation, must use great diligence to discern them; whence those are not without excuse who have denied altogether the existence of these organs.

This reptile feeds on worms, small bivalves, and snails. In this he resembles the salamander, but he bears fasting much better, being able to live two years and even more without aliment. When taken from his natural habitation, and exposed to the vicissitudes of the season, like other perfect reptiles, he hides himself during the winter, is inert, and refuses food.

The proteus does not live long if he is taken out of the water. When he becomes dry, he dies more or less quickly, according as the season is more or less warm, being less able to sustain life under such circumstances than fishes. But if the proteus die more speedily when out of water; in water, on the contrary, he lives better than fishes, since, *cæteris paribus*, he has not such frequent need of a renewal of the water as fishes have. When placed in a small vessel, in water at the temperature of 63°.5, the proteus, like fishes, rises at times to the surface to take in air by the mouth. In doing this, he opens his mouth as wide as he is able, and again rejects the air very quickly through the branchial apertures. In the act of taking in air, and passing it through these apertures, he makes a certain noise not unlike that made by a syringe, when a little air insinuates itself with the liquid into the tube; but when the animal is removed from the water, and then inspires air by the mouth, this noise is not heard. In the escape of the air by the branchial apertures, when the animal breaths in air, some minute bubbles remain attached to the margins of the apertures, or to the roots of the gills; and the gills themselves collapse and fall down against the sides of the head. On the contrary, when the air is received into the mouth while the animal is in water, it escapes freely through the branchial apertures, and rises in bubbles to the surface.

The necessity of inspiring air from time to time, is more or less great, according as the water is more or less impure; and it has a more direct relation to the temperature than to the quantity of water. It is greatest when the animal is removed from the water; he is then seen to take in air, and reiterate this operation; his breathing becomes weaker, and at the end of two or three hours he ceases to breathe. But if the water of the vessel have the temperature of 63°.5, and be also frequently renewed, he then has no need of rising to the surface to inspire air, and this is still less necessary if the water be in large quantity, or

gently flowing. The authors enclosed a proteus in a box, perforated with holes, which was then sunk in a large lake, and kept for three months and a half beneath the surface. At the end of this time, on examining the box, the animal was found extremely lively, which clearly shewed, that submersion in water for so long a period had in no way injured its vital economy. The temperature of the water, through the whole period, varied little from 66°. But if the temperature be under 54°, say from 45° to 48°, it is of little consequence to the proteus whether the water be much or little, fresh or stagnant, since at so low a temperature, he remains always as if immoveable at the bottom of the vessel, and never comes to the surface to inspire air. For four months together, two protei have been kept in a small vessel of water of the temperature from 43° to 45°.5, and have lived very well, although the water has not been once changed.

In the ordinary act of changing the water in which the animals are kept, if the fresh water be of a lower temperature than that which it replaces, the proteus becomes somewhat pale, and the gills, previously of a vermilion hue, turn pale, and collapse in an instant. This observation can, however, be made only in summer; for in winter, when the temperature is from 45° to 48°, if the proteus be placed in obscurity, and left perfectly quiet, the gills are always pallid, collapsed, and very small; and, should he be even molested, they do not appear so branched or red, as we see them when in a temperature varying from 68° to 72°; in which case, if the animal be at the same time well nourished, the gills are always in the erected state represented in the drawing. Should the water be raised successively to 77°, 88°, or 104°, it is observed, that at 88° the animal is much disturbed, expels bubbles of air through the branchial apertures, moves rapidly in the vessel, and attempts to escape: the gills become very red, and are so turgid with blood, that their points are turned upwards. And when the temperature is carried to 104°, the distress of the proteus is very great: he makes such movements and contortions of the body as if about to die, but which soon cease, if the temperature be reduced to its proper point. Hence it seems that the proteus is not able to live long in a temperature much above 77°.

With regard to the faculties of sense, those of hearing and seeing appear to be very weak; but those of touch and of smell, particularly the latter, exquisitely acute. When some small fishes were put into the vessel containing a proteus, it was amusing to see the animal direct his snout towards his prey, though he could not possibly see it, and afterwards seize it with the greatest celerity when a fish passed near him. But it may be asked, if the sense of sight be so weak, why is it that this animal so anxiously avoids the light? It is probable that the constant desire of obscurity arises from the painful action of light, not on the eye, but on the skin. From the experiments, however, of Sig. Rudolphi, it appears that this animal may in time be brought to bear the presence of light.

In a future communication, I propose to exhibit a general sketch of the anatomy of this animal, more particularly of its circulating and respiratory organs, illustrated by a few figures from the beautiful engravings with which the authors have adorned their work.

EDINBURGH,
January 20. 1821.

Observations on the Natural History and Structure of the Proteus Anguinus. By Prof. CONFIGLIACHI and Dr RUSCONI. (Continued.)

HAVING, in the former communication, detailed the leading circumstances in the natural history of the Proteus, I proceed now to exhibit a sketch of the anatomy of this animal, more particularly of its circulating and respiratory organs.

1. *Of the Skeleton.*

The authors commence their anatomical description of the Proteus, by treating first of the skeleton. The pieces which compose it, they observe, differ not only as to form, but also in regard to flexibility and hardness. Some parts are membranous, others cartilaginous, others between cartilage and bone, and others are entirely osseous. With respect to natural hardness, the inferior maxilla, and the arches which support the gills and form the branchial apertures, come first; next, the vertebræ; then the cranium; afterwards, the four extremities; and finally, the pelvis and scapula, and the two pieces which concur with the latter to form the articulation of the shoulder. The rigidity of the bones will doubtless encrease with age; but the authors cannot pronounce on the actual age of any of the animals they dissected, nor assert with confidence if they had arrived at their greatest size. In several, however, the organs of generation were perfectly developed; and one that was dissected, and which had been previously kept alive, in their possession, for ten months, did not appear to have increased an atom in size; nor were the bones different, in any respect, from those of other protei. In general, however, they regard the bones of the proteus as more tender than those of the aquatic salamander.

In the *cranium* of these animals there is no temporal fossa, nor zygomatic process, nor orbit to be seen; and the bones

themselves are so thin that the entire mass of brain is sometimes visible through them. The *temporal* bones send processes forward, which articulate with the lower jaw. The two *frontal* bones are long, and lie nearly in the same plane with the *infra* maxillary; but the cranium is a little depressed, in that part formed by the *parietal* bones. Both jaws are furnished with teeth, which are arranged in a beautifully symmetrical order along their respective borders. These teeth have a conical figure. In the upper jaw, their number is about 60; in the lower jaw there are 70, disposed in two rows parallel to one another. The lower jaw is horizontal, and has no ascending process where it articulates with the temporal bone.

The *os hyoides* in the proteus is short: its anterior branches extend backwards and outwards, and then bending upwards, proceed to be attached by a large tendon to the sides of the cranium, behind the articulation of the lower jaw *. The small arches which sustain the gills are three on each side; the first, or exterior one, is the largest; it is connected anteriorly with the posterior extremity of the os hyoides, by the intermedium of a little bone: the second, or middle arch, is also furnished with an intermediate bone, which is attached to the intermediate bone of the first arch: the third, or interior arch, has no intermediate bone, but is connected directly with the second by means of a cartilage. The relative size and position of all these parts may be seen in Plate VI. Fig. 1, where the bones of the head, viewed from below, are represented eight times greater than natural.

From the occiput to the extreme point of the tail there are 59 vertebræ, all of which, except the last, have an osseous structure. Of these, 29 belong to the neck and back, 3 to the sacrum, and 27 to the tail. The first vertebra, or atlas,

* In the Plates, the animal is exhibited in a reversed position, but in the anatomical descriptions, is supposed to be placed on his four feet; hence the terms anterior, or forward, look towards the head; posterior, or backward, towards the tail; superior, or upward, to the back; and inferior, or downward, towards the belly of the animal. The terms interior and exterior are used to denote relative nearness to, or distance, from the median line; and those of internal and external refer simply to the inside or outside of the animal.

has a peculiar form, possessing a dentiform process and articulating surfaces, on which the condyles of the occiput rest. All the others consist of a body, contracted in the middle like an hour-glass, and, except towards the extremity of the tail, each vertebra is furnished with four *articulating apophyses,* or processes, two anterior, and two posterior. The two anterior processes of each vertebra are covered by the posterior ones of the vertebra above it; and its two posterior ones cover, in turn, the anterior processes of the vertebra below: so that, viewed from above, the vertebræ seem to be placed in the manner of tiles.

Beside these processes, all the vertebræ, except the atlas and some of the *caudal*, have two *transverse* processes, which vary a little in form in different parts of the spine. In the third vertebra, these processes, which in the bone above were entire, separate into two portions of unequal length, and to the shorter portion is attached the rudiment of a rib. The same structure is continued downward to the ninth vertebra, where this partition of the process ceases. Below the ninth vertebra, these transverse processes are formed of two thin laminæ united together, and stand out from the body of the bone, like the unfledged wings of a young bird. Gradually these laminæ diminish and disappear, so that about the third or fourth caudal vertebra they exhibit only a simple spine; and this spine, continually becoming smaller, vanishes also about the tenth caudal vertebra. In addition to these transverse processes, the vertebræ of these animals have also their *spinous* processes, which spring from the extreme posterior and superior border of each vertebra. Beside having the dorsal spinous processes, the caudal vertebræ are furnished with two other spinous processes on the opposite surface of the bone, and which, from their position, may be named *ventral.* These spring from the roots of the transverse processes on each side, and proceeding in a parallel course, very soon unite, and form a canal, through which the bloodvessels, that are distributed to the tail, are continued. By the gradual diminution of the processes, this canal is lost before reaching the extremity of the tail.

So much for the bones of the cranium and spine. Of the skeleton there still remain the bones of the four extremities, the pelvis, and the shoulder. But it would be tiresome and useless,

say the authors, to give minute demonstrations of these; their figure, size, and position, are delineated of their natural size in Plate VI. Fig. 2, in which also the bones previously described are exhibited.

The authors having previously remarked that the bones of the proteus are less rigid than those of the aquatic salamander, proceed next to point out a few differences of form in the skeletons of these two animals. At first they appear very similar, but many points of dissimilarity occur on closer inspection. Thus, the transverse processes of the vertebræ in the two animals differ in relative size and form, as do also the costulæ or riblets that spring from them. In the salamander, the cartilages of the shoulder are large enough to extend over the breast, and perform the office of a sternum: in the proteus, on the contrary, they do not touch. Again, the pelvis, in the proteus, is attached by one extremity to the transverse processes of the thirty-first vertebra, and with the other end contributes, with the os pubis, to form the cotyloid cavity: in the salamander, the ileum is not immediately attached to the spine, but only by the intermedium of a little bone: and hence, in these reptiles, the whole pelvis is moveable. In the salamander again, there are only two vertebræ which form the sacrum; in the proteus there are three. Other differences might be noted in the bones of the tail and paws; but not to go into farther details of this sort, the authors prefer giving the results of their observations on the respective locomotive powers of these animals.

2. *Of the Movements of the Proteus in Water and on Land, compared with those of other Animals.*

Whoever shall attend to the particular structure of the vertebræ in the proteus, and their reciprocal connection, will easily perceive that the lateral movements of the head towards the trunk, and the lateral bendings of the trunk itself, will be somewhat limited in its superior part, where the articular apophyses form two planes inclined and converging in one and the same line: but as these processes gradually diminish in size, the capacity of moving laterally will be greater as we descend, and greatest of all when it reaches towards the eighth caudal vertebra, since there the processes entirely disappear. In the sala-

mander, the lateral movements of the trunk will be still more limited than in the proteus, by reason that the ridge, formed by the canal of the spinal cord, will impede the free motion of the articular processes on one another. We have observed attentively, continue the authors, and compared the movements and mode of progression of the proteus, and of the salamander and its larva, both in water and out of it; and have had the satisfaction of seeing that these movements, as well in swimming as in walking, correspond with the consequences previously deduced from a simple examination of the skeleton. A few of these observations they then proceed to relate.

The protei which, with this view, they submitted to observation, had already lived many months in earthen vessels, the bottoms of which were flat and of the figure of a parallelogram. To these vessels were adapted lids formed of many pieces; but so fitted together that the light was unable to penetrate, and the animals consequently lived always in complete darkness. When it became necessary to change the water, a portion of the lid was removed, and then the animal, by moving to the opposite side of the vessel, was able to continue in obscurity.

It has been already observed, that the proteus, in ordinary circumstances, remains as if immoveable at the bottom of the vessel; but at once begins to move with more or less rapidity as the light is let in upon him. Of this fact, the authors availed themselves in their observations on the movements of these animals. Having first discovered in what part of the vessel the animal reposed, the piece of lid above him was gently raised, so as to expose him to light. As soon as he felt its influence, he instantly began to move and withdraw himself to that part of the vessel which was still dark. In making this movement, however, he did not always employ the same kind of motion. Sometimes he drew up the lower part of the trunk and the tail, or rather gathered himself up in the manner of a serpent. In doing this, he made use only of the muscles of the spine, and not of those of the hind limbs, which, during this action, remained quite at ease, and followed the trunk as if they had been paralytic. When the body was thus gathered up, and formed into a serpentine line, the animal thrust the hind limbs to the bottom of the vessel; then stretching forward the whole trunk,

he began, at the same time, to move, one after another, the fore-limbs; so that, making use of the hind limbs as serpents use the ventral scales, and employing the fore-limbs to sustain the head and chest, the animal proceeded slowly along, crawling in part, and in part moving like a biped animal.

Sometimes, again, the proteus sought to avoid the light by making use only of the limbs, keeping then the body and tail in a right line, and moving the limbs alternately as quadrupeds do when they move by steps. At other times, he moved in a way both singular and amusing; for gliding along so as to graze the bottom of the vessel, and supporting himself on the fore-limbs, he kept the hind ones applied to the sides of the trunk; so that the body, from the shoulders backward, was entirely suspended and gliding; and from the shoulders forward, was sustained on the fore-limbs, which moved alternately, and with much quickness, along the bottom of the vessel. This mode of progression was a mixture of the gliding of fishes and the walking of biped animals. A fourth mode in which the animal sought escape from the light was by suddenly betaking himself to swimming. This always occurred when the whole vessel was at once uncovered. At the same time, he glided rapidly over the sides of the vessel, and made attempts to escape out of the water, in order to withdraw himself from the light, which so greatly distressed him. Whilst the proteus thus glides along the sides of the vessel, his motions resemble those of the lamprey, and, like that fish, he drops to the bottom as soon as he ceases to move. The lamprey, however, aids his motions by the incurvations of the trunk, while the proteus glides along chiefly by the use of the tail, which moves to either side with great facility and quickness, exactly as occurs to fishes. This difference arises from the spine of the lamprey being wholly cartilaginous, and therefore equally flexible in every part; but in the proteus, the spine is entirely osseous, and incapable of any considerable degree of flexion, except towards the tail.

Beside the resemblance above noticed in the motions of the lamprey and proteus, it is observed that the latter animal, when he swims, makes no use of the feet, either to start him in the first movement, nor afterwards to sustain his equilibrium. His limbs continue applied always to the sides of the trunk, and may

be compared to the four oars of a boat, floating freely in the water, but attached by leathern loops to the sides: if in this state the boat be urged forward by the winds, the oars are soon forced back by the water and laid alongside the vessel. From not making use of their limbs in thus gliding through the water, it sometimes happens, that these animals, in the act of changing their direction, roll over, and afterwards *right* themselves, as soon as they have got on their new course. The same thing occurs to lampreys, which, in gliding along, sometimes roll over: and when they descend to the bottom, if they wish to remain at rest, and preserve a rectilinear position, they are constrained to attach themselves to some solid substance, by making use of their mouth, which adheres on the principle of suction, else, having neither feet nor fins to maintain themselves straight, they are obliged to lie down on their sides. These facts seem to shew that the principal use of the fins in fishes is to maintain the body *in equilibrio*, as the learned M. Cuvier has observed.

With respect to the movements of the adult salamander in water, as compared with those of the proteus, the authors observe that he is less agile. This may arise from various causes, but principally from the form of the tail, which is not only of less size, but is less adapted for swimming. The larvæ also of the salamander are less agile than the proteus, but in that state they swim with more facility than afterwards. This probably arises from the tail in the larva state being proportionally larger, and also from the larva possessing a lower specific gravity than the adult animal, except when the latter has recently emerged from his winter torpor. That the larvæ have a lower specific gravity than the adult salamanders, is inferred from the fact that they are able to sustain themselves in water, at whatever height they please, only by moving, from time to time, in a slight degree, their claws and tail. It is beautiful to see them continue thus suspended, and as if balanced, on their four limbs in the water, like a bird librating in the air: and afterwards, by striking the water behind them, and by a slight movement of the tail, transfer themselves from one place to another.

The authors subjoin a few remarks on the movements of these several animals on land. Salamanders move from place to place only by a simple motion of the limbs. They have neither the

ventral scales, nor the long ribs of the serpent, which are considered to serve as organs of locomotion. Their trunk stands supported on the four limbs, and does not touch the ground but occasionally, and then only when they move by steps; so that they move on land with the gait common to all quadrupeds. As the larva approaches the period of transformation, his movements resemble those of the adult salamander; but when young, the limbs are so slender and weak, as to be unable to sustain the trunk. At a later period, when taken out of the water, he is able to move a little to the right and left with the anterior part of the body; but with the posterior part, he remains as if fixed to the surface on which he stands.

Not dissimilar to the larvæ above mentioned are the protei, with regard to the capacity of progression out of water. They possess not the incurvations of the trunk, by which they would be enabled to crawl; nor do their four limbs serve them for creeping, nor for moving like quadrupeds. If they bend to the right or left, the entire body forms but a single curve; and on resuming a straight line, the body is found always in the same place. It is true, that, sometimes by pushing with the hind-limbs forcibly against the ground, and stretching forward the trunk, they are able to move a little in advance; but this is done with the greatest difficulty, from the circumstance that their body being smeared with a viscid mucus, adheres to the surface on which they attempt to move.

It thus appears, that, in water, the proteus has the singular and surprising faculty of moving himself in the manner of quadrupeds, of serpents and of fishes; and that he adopts now one kind of movement and now another, according as his necessities urge him to move with greater or less rapidity. His whole structure seems to destine him to live continually in water, and unfits him for the life of a land animal; but the aquatic salamander has limbs sufficiently strong to move on land; and the authors have been assured by men who are employed in fishing in the streams they inhabit, that at certain seasons they go on land.

We find no particular account of the muscular system, but the authors proceed next to treat,

3. *Of the Organs of Digestion.*

The *tongue* of the Proteus through its greater part, is fleshy, and is free both at its apex and on its edges; it is supported, as usual, by the os hyoides. The passage from the *fauces* to the stomach is very short; nor is it easy to fix the place where the *œsophagus* terminates. The *stomach* proceeds in a strait line, is only a little larger than the intestines; and, on a first view, appears like a portion of them. The membrane that covers the fauces, is continued into the stomach and intestines, forming various *rugæ* or longitudinal plaits, more than six or seven in number. These plaits begin where the œsophagus commences; they gradually disappear towards the middle of the stomach, and become again conspicuous as they approach the pylorus, where they are more raised than in any other part of the canal.

The *intestines* are enveloped in a duplicature of peritonæum, which is continued through their whole length. They are formed of very fine and transparent tunics, and make several convolutions in their course. Their size is nearly uniform throughout. In protei recently taken in summer, they always contained fœces; but in winter, neither the stomach nor intestines contained any remnants of food. The internal organs of generation in the male and female, as well as the kidneys, open into the intestines, near the anus.

The *liver* begins and terminates in a point; it is so long, that it extends through two-thirds of the abdomen. In its left margin there are some fissures; and in one deeper than the rest the gall-bladder is lodged. The colour of this viscus is reddish, approaching to that of rust of iron; and its surface is every where speckled with small blackish spots. Its figure is convex below, and concave above towards the spine.

The *spleen* is a finger's breadth in length, and is placed by the side of the stomach, to which it is attached by *vasa brevia* and a doubling of the peritoneum.

The *pancreas* is only half the length of the spleen; and is attached to that portion of the alimentary canal which is immediately below the stomach, and called *duodenum*.

On the whole, the organs of digestion, as well primary as secondary, much resemble those of the aquatic salamander. In these last, however, the stomach is somewhat curved, and placed

a little transversely; and the intestines are evidently divisible into large and small, and are, moreover, furnished with fatty appendages. A general idea of the relative size and position of these several viscera, is exhibited in Plate VII. Fig. 1.

4. *Of certain Opinions of MM. Schreibers and Cuvier, regarding the length and figure of the Alimentary Canal.*

Before quitting these organs, it is proper to notice a difference of opinion between MM. Schreibers and Cuvier, with respect to the length and figure of the alimentary canal. The former exhibits figures, from which we learn that the intestines, before they open externally, make several convolutions; the latter, on the contrary, affirms, that the alimentary canal proceeds almost in a straight line from the mouth to the anus. A simple statement of the appearances exhibited by the several protei examined by the authors, and their observations thereon, will account for this disparity of opinion, and explain its cause.

The three first protei they dissected, had been preserved about seven months in ardent spirits, (brandy,) and in all the three the intestines were convoluted. They then killed and injected a living proteus, and immediately afterwards opened the abdomen, and found the intestines, as in the former examples, to possess a convoluted form. The following summer they received eight other protei, five of which had died on the journey, and were put into spirits, and the three others arrived in a very lively condition. They proceeded at once to anatomise the five dead ones; and found in all of them the intestinal canal almost strait, as described by Cuvier. Perplexed by these opposite appearances, they formed several conjectures as to their cause; but these afforded little satisfaction to the mind, when, in the midst of their doubts, accident at length enabled them to discover the truth. In the succeeding autumn, they obtained a fresh supply of living protei, similar in all respects to those which had arrived in May. One of these was killed and injected; and afterwards, on opening the abdomen, the intestines appeared convoluted, and similar in length to those of the protei *first* examined. These facts being observed and recorded, the animal was put into spirits for a second examination at a future

PLATE XI.

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Fig. 1.

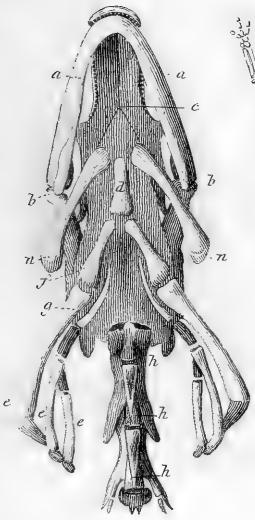


Fig. 2.

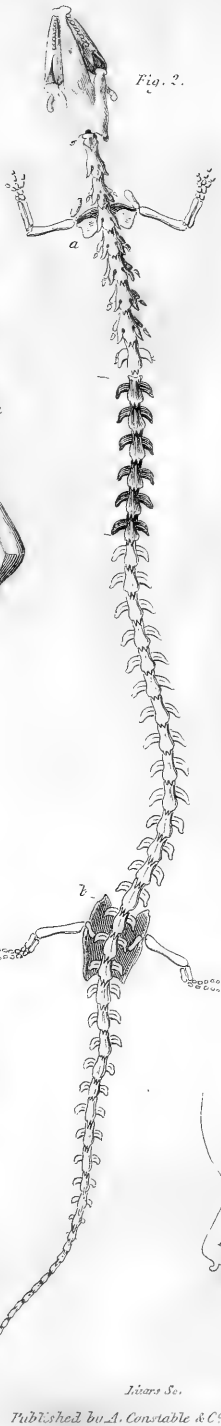
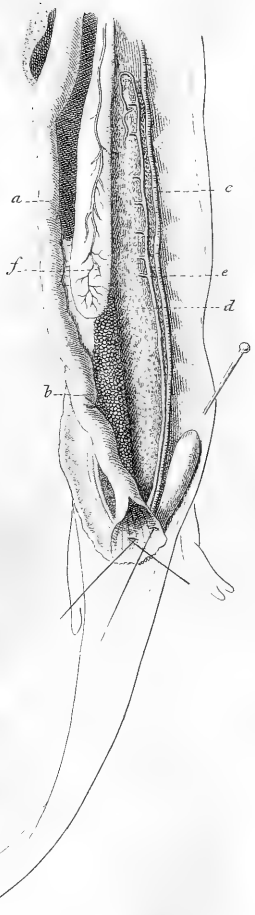


Fig. 3.



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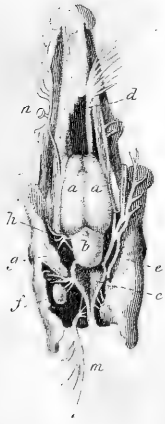

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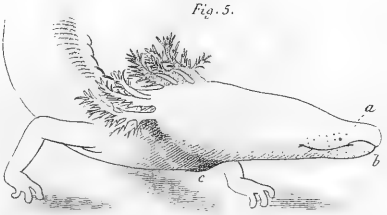

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Edin.r Phil. Jour. Vol. V. Pl. II. III.

Fig. 1.

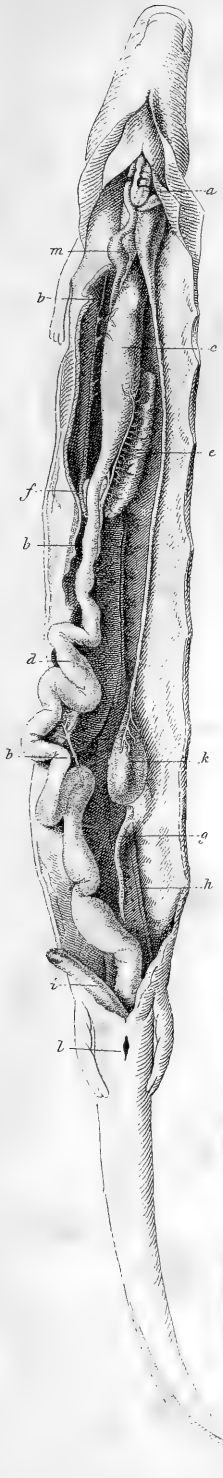

Fig. 2.

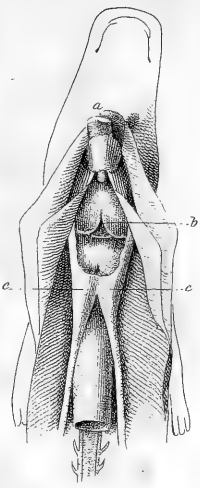

Fig. 3

Fig. 6.

Fig. 5.

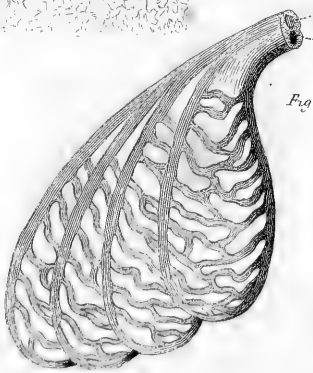

Fig. 4

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period. In six or seven days, he was taken out of the spirits to examine the injected vessels; when casting their eyes on the intestines, the authors observed, not without surprise, that the alimentary canal, which, a few days before, was convoluted, soft and transparent, had now become not only opake, but so much shortened, that had they wished to describe it, they might have said in the language of Cuvier, "*qu'il alloit presque en ligne droite d'un bout à l'autre.*" This fact, though at first it excited surprise, brought with it much satisfaction, since it was easy to comprehend, that the shortening of the alimentary canal was owing to the animal having been placed in ardent spirits, while the intestines yet retained their irritability. Of this opinion they afterwards obtained proofs in various ways; and, in particular, having, on one occasion, opened the abdomen of a living proteus for another purpose, they observed the intestines to be at first convoluted and transparent; but under exposure to the air, these organs gradually contracted to such a degree, that, at last, under the eye, they became knotty and opake, and continued to wrinkle and shorten more and more; so that, after the death of the animal, (which occurred in about half an hour,) they were brought nearly to a strait line. Instead of spirits, the animal, in this its dissected state, was placed in water. On visiting it the next day, the alimentary canal was found so much relaxed, as to have recovered its former length; and when the animal, now destitute of irritability, was placed in spirits, its intestines maintained their convoluted form, and did not visibly shorten afterwards but a very few lines. From these and other facts, the authors infer with confidence, that the alimentary canal of the proteus is always naturally convoluted; and that when it is seen to proceed in a strait line, it has suffered contraction from the action of ardent spirits, or some other agent upon it, while still possessed of irritability.

Experiments similar to the foregoing were tried on the intestines of the salamander and frog. These animals resist death longer than the proteus, and may be considered to possess greater irritability; but in them the contraction of the intestines was not observed to equal, in any degree, that of the proteus, arising, probably, from some difference of structure. These obser-

vations, say the authors, not only illustrate certain facts regarding the proteus, but may apologise for those learned writers, who, from not having had the opportuntity of dissecting this animal when recently dead, have deviated, in their anatomical descriptions, some little from the truth.

5. *Of the Organs of Circulation.*

The heart of the proteus is lodged in that triangular space which is formed by the branchial arches. Its situation and size may be seen in Plate VII. Fig. 1. Its structure is simple, consisting, like that of the frog, of one auricle and one ventricle. In figure, also, it resembles the heart of the frog, but is somewhat smaller in proportion. Its auricle is placed forward, and over the ventricle; is slightly toothed on its margins; and to the eye seems as large as the ventricle itself.

From the base of the heart on the right side, springs a very short canal, which proceeds straight forward; but before it gets beyond the auricle, by which it is covered, it expands into a bulbous form. This short canal, the only one that goes out from the heart, is of a soft fibrous texture, similar to that of the heart itself. The bulbous part, on the contrary, possesses great strength, and is opake and tendinous. Hence it is, that whether it be empty or full of blood, it exhibits always a whitish pearly colour, different entirely from the other parts of the vessels, which, when full of blood, appear of a reddish or russet hue.

From this bulb proceed two large arteries, which, almost immediately on quitting it, separate from each other, and are directed, on either side, towards the branchial arches. These two arteries, for greater clearness and convenience of description, are called the two *primary* trunks; but the authors will speak only of one, since what is said of one will apply equally to the other.

The *primary* trunk, then, of the right side, very soon after quitting its fellow, gives off a branch which runs under the first arch through its whole length, where it sends off two arteries, one to the first gill, and the other to the muscles of the os hyoides; afterwards, abandoning the arch, and turning upward and inward, it goes to the roof of the occiput. This *first* branch from the

primary trunk, beside its office of conveying blood to the gills, corresponds, in other respects, to the common carotid.

The other or *second* branch of the primary trunk, is conducted beneath the second or middle arch; and having reached the place where the third arch joins with the second, it sends off an artery which runs along the margin of the third arch, and goes to form the *third* gill. The main portion of this second branch then proceeds along the middle arch; and a little before reaching its posterior extremity, sends another artery for the formation of the *middle* gill. After this, turning upward and inward, it goes for a short way towards the occiput; and getting near the second vertebra, it bends backward and downward by the side of the spine; towards the fourth vertebra, it meets, under the spine, with its fellow from the opposite side, and both then uniting, form together the *aorta descendens*, which is continued towards the tail. It is not necessary to follow the aorta through all the branches it gives off in its descent. We must not, however, omit to mention, that this second or chief branch of the *primary* trunk, before it bends backward and downward, sends off three branches, and makes also an anastomosis with the common carotid. Of the three branches, the first is sent to the air-bladder, and to the ovaries in the female, and testicle in the male. The second is distributed to the parts about the temple; and the third is the vertebral artery, which, after giving off some twigs to the occiput, enters the canal of the vertebræ, and descends towards the tail. This description of the circulating system, is accurately represented in Plate VII. Fig. 3.

Let us next follow the course of the branchial arteries, destined, as we have seen, to form the gills. Immediately on quitting the branchial arches, they are continued out of the head; and scarcely have they gone out, than they divide into many branches, which, in their turn, subdivide into others, and these, again, into minute ramifications, in such a manner, that the three gills resemble three little plantules, rooted to the sides of the occiput, and furnished with many minute leaflets. The reason why the structure of the gills is so similar to that of a leaf, is, that the fine skin which lines the fauces, invests the arteries as they traverse the arches; and, following them externally, clothes them as they divide: but as they approach their last divisions,

there this skin, instead of surrounding them individually, as it had done in the larger branches, expands into a membrane, which comprises between its two surfaces all the ultimate ramifications into which each lesser branch has spread. A good idea of this foliated structure may be obtained, by inspecting Fig. 4. Plate VII., in which a portion of one of the leaflets is represented, and where the blood of the branchial artery, of a dark colour, is seen moving round the margin of the leaflet. In its course, it continually passes off transversely through the net-work of vessels that forms the expanded portion of the leaflet; and, losing in its progress its dark colour, and acquiring a florid hue, it is finally collected from the several leaflets into the branchial vein at the root of the gill *.

Scarcely have these branchial veins reached the roots of the gills, than they separate from their accompanying arteries, and entering between the extreme points of the arches, proceed superficially towards the top of the spine. The vein of the first gill enters between the first and middle arches, and soon after pours its blood into the *first* branch of the *primary* trunk, or that named Common Carotid. The two other veins, on the contrary, in re-entering the head, pass between the middle and third arches: Afterwards, they unite into a single canal; and thus reunited, they deliver their blood into the second branch of the primary trunk, a little before that vessel sends off its branch to the air-bladder and sexual organs. This distribution of vessels conveying dark blood to the gills, and of those which carry back florid blood from those organs, is represented in Fig. 3., as above. Of the subsequent distribution of

* The authors remark, that the structure of these leaflets of the gills is visible only in *dead protei*, especially in those which, from having been placed in spirits, have lost their transparency. In the living animal, while remaining in water, they can be seen but with the greatest difficulty; and then only when very turgid with blood. The reason is, that the membranous expansions, between which the ultimate ramifications of the arteries and veins are comprised, are so exceedingly fine and transparent that an inexperienced eye is unable to perceive them; and an observer, in such circumstances, being unable to use a high magnifying power, and seeing only the vessels which bound the margins of the leaflets, have supposed the gills to be formed rather like a dissected than entire leaf, or resembling somewhat the horn of a stag.

the blood by the vessels given off from the aorta, it is unnecessary to say more; but of the return of this blood to the heart by the veins, it is proper to take some notice.

There are three principal veins which reconvey the blood from the different parts of the body to the heart; two corresponding to the *jugulars*, and the third to the ascending *vena cava*. The two former, after receiving the blood which returns from the head, pour it into the cava, where that vein is so dilated as to form a sort of sinus. Into the cava, also, at different parts, is poured all the blood returned from the trunk. Thus two large veins which ascend the spine on each side of the aorta, and receive the blood of the dorsal veins in their progress, enter the cava much below the middle of the trunk. The blood of the air-bladder and organs of generation is poured, by a single vein, into the cava about the middle of the kidney. The vein which collects the blood from the intestines, arises near the termination of the alimentary canal; and proceeding between the expanded portions of the peritonæum that form the mesentery, gains the neighbourhood of the stomach: there its trunk, which may be called the *vena porta*, is spread entirely through the concave surface of the liver. After circulating through that viscus, the blood is again collected into one vein, which, traversing the edge of the liver, pours its blood into the cava at the point where that vessel itself quits the liver to continue its course to the auricle.

6. *Of the Organs of Respiration.*

In the preceding chapter on the organs of circulation, the authors have described, with all the accuracy they were able, the course of the branchial arteries and veins to and from the gills, which might be considered as including a description of the respiratory organs; but as the *proteus anguinus*, besides being furnished with gills, is provided also with two air-bladders, which, from a resemblance to the lungs of the aquatic salamander, have been regarded as two real lungs, it is necessary to give a more particular description of those two organs.

In the bottom of the fauces, and exactly in the middle of that space which lies between the branchial apertures which communicate with the gills of each side respectively, there is a

small cleft or chink, the margins of which do not rise above the surface, nor possess a cartilaginous structure. This very small chink or glottis, as it may be called, communicates with a very short canal, which proceeds backwards above the heart, between the pericardium and pharynx. This canal exteriorly, and on the side next the heart, is furnished with two very fine muscular expansions, the fibres of which springing from the median line of the canal itself, are disposed like the beard of a pen, and directed back towards the branchial arches. The office of this very subtile muscular substance is, doubtless, that of dilating the canal, and opening the glottis. The canal itself, before getting beyond the heart, opens, by a semilunar aperture, which has cartilaginous margins, into a large conical cavity, Plate VII. Fig. 2. From this funnel-shaped cavity, are continued two membranous canals, which, keeping the stomach between them, descend towards the tail: but before reaching the lower-third of the trunk, they begin to dilate, and by degrees expand, so as to acquire the form of two small flasks; the left descending a little lower than the right. These two canals are attached to the spine, by duplicatures of the peritoneum, in which, through their whole length, they are involved. The two little flasks or bladders have no cells nor partitions internally, but are perfectly smooth membranes. Were it possible to dilate the two canals to the size of the bladders in which they terminate, these organs would then acquire very exactly the form of the lungs of the salamander. The two bladders are situated one on each side of the abdomen; that of the left side is represented in Plate VII. Fig. I., and also the narrow canal leading to it. In protei that have been some time in spirits, the canals become entirely closed and quite impervious to air; but in those recently dead, the bladders are easily dilated by air blown through the canals.

The authors having observed, that, when a living frog or salamander is laid on his back, the abdomen then opened, and its walls fastened back, the lungs, during the struggles the animal makes, sometimes dilate and contract for a certain time, were desirous of ascertaining, by a similar experiment, if the small portion of air which the proteus takes into the mouth found its way into the two little bladders above described. A proteus

was, therefore, fastened on a board, the abdomen was opened, and its walls kept asunder by means of pins, in order to observe what would happen to the air-bladders. In a few minutes the animal began to take air into the mouth, and afterwards panted with a quickness always increasing for a quarter of an hour; after which his pantings became weaker, and at the end of half an hour he died. While the proteus was thus agitated and panting, they watched attentively the two air-bladders, but did not see in them the smallest movement, which could indicate the entrance of air. They saw, however, that these bladders gradually contracted from the action of the external air; and at length became corrugated to such a degree, as to resemble in figure two fleshy bodies, of the form and size of two grains of wheat. The air which entered the mouth escaped entirely by the branchial apertures, forming mostly minute bubbles, which, for some time, remained attached to the edges of those apertures.

7. *Of the Organs of Generation.*

The authors regret, that, under this head, their observations are not so complete as they could have wished; and that some points relating to it are still enveloped in obscurity.

Of the five protei dissected in the month of May, as before stated, there were two in whom the sexual organs were so fully developed, that no doubt could remain of the one being a male, and the other a female. In the male, the testes were attached to the air-bladder. To the eye they appeared to be a congeries of most minute globules; but when examined under the microscope, their substance was nothing else than a mass of most minute vessels, disposed longitudinally, and extending in a serpentine line from one end of the testicle to the other. Towards the posterior part of the organ, where it had somewhat of a pyriform figure, these minute vessels enlarged and separated a little from ecah other. Continuing the examination, they observed, towards the extremity of the alimentary canal, a circular ring, evidently formed by the internal tunic of the intestine, from which proceeded many longitudinal threads, which extended to the margin of the anus: but nothing was seen like a receptacle for semen, nor penis, nor *vasa deferentia*. A vessel seemed to extend from the posterior part of the testicle, and open into the

intestine; but whether this be the excretory duct of the testicle could not be determined. From an observation of M. Schreiber, the authors conjecture, that the testes of the proteus are subject to some remarkable changes with the increase of years, like those of the aquatic salamander, in which the testicle at first is formed of one spherical body; afterwards of two, and subsequently of three; and not of two only, as M. Cuvier has stated. The position and form of this organ may be seen in Fig. 1. Plate VII. (*g*).

The *ovaria* of the female are situated under the kidneys, and by the side of the rectum. They are enveloped in peritoneum, and have connection both with the spine and air-bladder. In protei recently dead, and not yet put in spirits, the ovaries appear an oblong mass of albumen, in which are suspended a vast number of minute ova. The oviducts do not commence near the heart, as in frogs and salamanders, but towards the anterior third of the trunk. They descend by the side of the spine, along the exterior margins of the kidneys; and having reached the posterior extremity of the kidneys, they approximate and terminate into the intestine by a common aperture, a small distance from the anus. In the proteus dissected by M. Cuvier, he describes "les oviductus tres-longs, et faisant beaucoup de festons, comme ceux de la salamandre;" but the authors have not met with such appearances. In protei preserved in spirits, the oviducts were always found straight; and in those recently dead they were much longer, but did not form those twistings and windings which the ducts of the salamander make before they enter the intestine. See Plate VI. Fig. 3.

8. *Of the Organs of Secretion.*

The kidneys of the proteus are so long as to occupy the lower half of the trunk. In structure, they much resemble those of the salamander; but in their anterior part are two curvatures or sinuses, in which the two air-bladders are respectively lodged. The ureters are much convoluted anteriorly, but extend in a straight line towards the posterior half of the organs, where they gradually approach each other, and finally unite together at their termination by one common aperture in the intestine. It must also be remarked, that, in the male proteus, as in the salamander, the ureters commence high up on the spine, and descend

afterwards in a right line, till they reach the anterior point of the kidneys, where they make many twistings, and pursue a serpentine course, till they arrive at the lower half of those organs. In the females of these reptiles, on the contrary, the ureters are less convoluted, and do not commence at any distance from the kidneys; whence, it is probable, that from this difference of form, the ureters of the male may exercise some other office besides that of conveying the urine. In Fig. 3. Plate VI., the kidney of a female may be seen.

But though the kidneys and ureters in the proteus and salamander bear so near a resemblance, the form of the urinary bladder in the two animals is quite different. In the salamander, this organ is short, and its fundus bifid. In the proteus it is long, and has a simple fundus; so that it resembles more an appendix cœci of the intestine, than an urinary bladder. It is annexed to the intestine in a point diametrically opposite to that into which the two ureters are inserted; in other words, it is inserted into the wall of the intestine that looks downward, while the ureters terminate in the wall that regards the spine. In the proteus, therefore, as in other reptiles of the same family (Batraciens,) the ureters do not terminate in the bladder, but discharge themselves directly into the intestine, at a point opposed to the bladder. This fact has led many, and among others Townson and Schreibers, to doubt if the organ named the urinary-bladder, be, in frogs and salamanders, a real receptacle for the secretion of the kidneys, or destined to some other office. Townson, supposing the urine poured into the intestine by the ureters to be at once discharged with the fæces, suggests the idea, that the bladder above mentioned may be regarded rather as a reservoir of water absorbed from without, and destined to some particular use in the animal economy. His words are, " Cum nunquam bibant hæc animalia, opus tamen sit iis tantopere aqua, probabile mihi videtur, aquam cute absorptam, aut ejus partem induci in vesicam, tanquam in vas quod eam servet; atque inde distribui, prout economia animalis requirat, eodem ferè modo, quo fluidum receptum in ventriculum aliorum animalium inde distribuitur *." That the skin of frogs absorbs water, seems demonstrated by the re-

* See Townson, Observationes Physiologicæ de Amphibiis, &c.

cent experiments of Dr Edwards; but that the water so absorbed is conveyed into the aforesaid bladder is merely a conjecture; and, as appears to the authors, wholly without foundation. But if we reject Townson's conjecture, what must we think of the fluid with which the bladder, both in frogs and salamanders, is so frequently filled? If it come not from the kidney, from what other gland or organ can it proceed? Is it secreted by the bladder itself? This supposition is not probable; for the walls of the bladder are not sufficiently furnished with vessels to secrete so great a quantity of fluid. From some experiments not yet published, the authors are disposed to regard this organ as a true receptacle of urine.

9. *Of the Organs of Sense.*

The *brain* of the proteus very much resembles that of the salamander, especially when in the larva state. The two hemispheres are nearly cylindrical; the lateral ventricles are large, and in their posterior extremity lie the *corpora striata.* There is also a third ventricle, and two optic thalami, very small, and of an oblong form. The carotid artery, on entering the cranium, makes a twist around the aperture, and sends off the opthalmic artery, which is continued, between the cranium and hemisphere, to the eye: the principal trunk of this vessel then proceeds beneath the brain, and, spreading into beautiful ramifications, is distributed to the two hemispheres, &c. See Fig. 4. Plate VI.

The *eyes* of this animal are situated, and we might say buried, between the anterior extremity of the masseter muscles, which go to be inserted in the lower jaw, and the posterior extremity of the canal of the nostrils. They are inconceivably small, and are placed, not in an orbit formed by bone, but in a web or tissue, formed of venous and nervous ramifications. No muscle nor optic nerve has yet been discovered; but on raising the hemispheres very gently, a very subtile nerve, similar to the fine thread of a spider, seemed to go to the foramen, through which passed the ophthalmic artery, as seen in Fig. 4. The crystalline humour is large in proportion to the other parts, and has a spherical figure: the sclerotica is not white, but blackish; of the other parts we dare not say more; for, from their extreme minuteness, it is difficult to speak of them with precision.

The organ of *hearing* in the proteus is very simple. It has neither membrane nor cavity of the tympanum; but consists only of a large cavity formed in the bones of the cranium, in which is seen the little sac containing the *ossicula* or small bones: this cavity is also furnished with a *fenestra ovalis*, closed by a bony plate. On raising the little sac the semicircular membranous canals appeared to come into view, but of this the authors do not speak with confidence. This organ, as seen by them, is represented in Fig. 4., as above.

The organ of *smell* in the proteus differs entirely in structure from that of the salamander, and the other animals of the same family; and if we are entitled to infer the perfection of the sense from the structure of the organ, the *proteus anguinus*, in this respect, will surpass all other known reptiles. The external aperture of the nostrils is exceedingly small, and of a triangular form; its position is represented in the profile view, Plate VI. Fig. 5., and corresponds internally with a canal that is soft and pulpy through its whole length. The olfactory nerves are rather large; these nerves, after passing by the bulbs of the eyes, go out of the cranium, and divide and ramify on the soft substance that lines the nostrils. If with a needle the canal of the nostrils be broken down, and its substance removed, preserving at the same time the nervous filaments distributed upon it, the olfactory nerve is then resolved into a pencil of filaments, as delineated in Fig. 4.

Conclusion.

Having thus terminated the anatomical description of the Proteus Anguinus, the authors proceed to examine the two following questions; *firstly*, Whether it be true, as many believe, that this reptile can respire, at the same time, by gills and by lungs? *Secondly*, If the *Sirena lacertina* is to be regarded as a larva or a perfect animal? To determine these questions, it will be necessary to compare the branchial structure, the organs of circulation, and the supposed lungs of the proteus, with the corresponding parts in the *sirena* and in the *larvæ* of the salamander and of frogs.

With respect to the branchial structure, there is a remarkable difference, not only as to form, but to texture, between the arches of the proteus, and those of the siren and larvæ above mentioned. In the siren and larvæ, the branchial arches are

four on each side, and their margins are furnished with small points,—in the proteus, there are but three on each side, and these are smooth. The arches of the proteus have an osseous structure,—those of the siren and larvæ are cartilaginous. This difference did not escape M. Cuvier, who, speaking of the proteus, says, "l'appareil osseux qui porte les branchies, est beaucoup plus dur que ne l'avons trouvé dans la *sirene*, et dans *l'axolotl*:" and in his anatomical description of the latter animal, he farther says, "*l'appareil qui supporte les branchies à de grands rapports avec celui de la sirene*, et je crois que, lors de la metamorphose, il en reste une partie pour former l'os hyöide de la salamandre *." Now, if the branchial arches of the siren be, as M. Cuvier asserts, entirely cartilaginous, although the cranium, the lower jaw, and the vertebræ be perfectly ossified; and if these arches, both in form and number, be similar to those of the *axolotl*, which M. Cuvier himself regards as a larva,—may it not be presumed that the former animal is a larva also? If, farther, the branchial arches of the proteus, which is a *perfect* animal, be osseous, and entirely different from those of the siren and all the larvæ hitherto known, have we not in these facts the strongest reasons for regarding the siren as an *imperfect* animal, and, therefore, essentially different from the proteus?

With regard, next, to the organs of circulation, there are, in the larvæ of the frog and salamander, as many arteries given

* The authors here observe, that they have not themselves had an opportunity of anatomising the sirena lacertina; and, therefore, with regard to its internal structure, they trust entirely to the descriptions of M. Cuvier, who has written largely upon it.

It may not be out of place to add, that, in the new arrangement of M. Cuvier, the *Proteus anguinus* stands in the class Reptiles,—order Batraciens,—genus (containing as yet only one species,) Proteus. Besides internal lungs, it bears externally, like the larva of the salamander, three gills on each side of the neck, which it appears to retain through life.

The *Sirena lacertina* occupies the same class and order, and is another genus consisting only of one species. It is said, like the proteus, to retain through its whole life, three gills on each side the neck, and to possess, at the same time, lungs internally.

In the same class and order is placed the Axolotl of the Mexicans, or Sirena pisciformis of Shaw. It belongs to the genus Salamandra, of which it is a species. Some allege that it also always retains its gills.—Vide *Le Regne Animal*, tom. ii. p. 101,—102.—Transl.

off on each side by the trunk that springs from the heart, as there are branchial arches, viz. four. In the siren and axolotl, (which have also eight branchial arches,) M. Cuvier speaks only of six arteries, three on each side, going to the gills; but as, by the aid of injections, we have found, say the authors, that, in the larvæ above named, there are eight vessels, and that the artery which runs along the interior arch of each side, and which M. Cuvier has not seen, is that which in process of time becomes the pulmonary artery, so, guided by analogy, we hold it for certain, that, as the siren is furnished with eight branchial arches entirely similar to those of the other larvæ, there are also eight arteries, four on each side, corresponding to them. And, proceeding on this opinion, we may remark a striking difference in the circulating system of the siren and proteus, since the artery, properly called Pulmonary, which is found in the siren and larvæ above mentioned, does not exist in the proteus. Doubtless in the proteus, the air-bladder, like every other part of the body, is duly supplied with blood; but the blood sent to it is furnished by an artery coming off, on each side, from one of the aortic trunks, and which artery, descending along the canal of the bladder, gives to it a branch, and is then continued to the ovary or testicle in each sex respectively.

Besides these differences in the arterial, there are others in the venous system; for the vessel which returns the blood from the air-bladder of the proteus, does not empty itself directly into the cava or the auricle, as is observed in other reptiles; but into the vein which carries back the blood from the organs of generation, which itself enters the cava above the middle of the kidney; hence in the proteus, not only the true pulmonary artery, but the vein also, is wanting. This anatomical fact, ascertained by repeated injections, might alone be sufficient to demonstrate, that the two air-bladders with which the proteus is furnished are not true lungs: but as some, perhaps, may not yield to the force of these arguments, we shall continue the comparison, especially as applied to the organs of respiration.

In the larvæ of the frog and salamander, the *trachea* opens directly into the lungs. These organs have the form of two sacs, and, from being longer than the trunk, cannot be extended in a straight line through it, but at the lower end are folded

a little from one side of the abdomen to the other. So, in the siren, we see the trachea to open directly into the lungs, which, as in the above-mentioned larvæ, says M. Cuvier, "sont deux longs sacs cylindriques, que s'étendent jusqu' à l'extrémité posterieure de l'abdomen, et se replient même alors en avant." But, in the proteus, neither do the supposed lungs reach to the pelvis, nor does the supposed glottis open into the air-bladders, but issue in a cavity which communicates with the air-bladders by two long conduits. Thus, then, the structure of the branchial arches, the distribution of the bloodvessels, and the form and size of the lungs in the proteus, differ entirely from the corresponding organs in the siren and larvæ of the salamander.

If, farther, we consider the mode in which frogs and salamanders respire air, and compare it with that of the proteus, we shall obtain still farther evidence of the differences subsisting between them. All zoologists, including M. Cuvier, now admit that frogs first receive air into the mouth through the nostrils only, and from thence force it into the lungs by an action resembling deglutition. But neither the proteus nor the siren are able to respire in this manner; for the nostrils in the former do not open into the mouth, but beneath the upper lip; and in the siren, "*les narines, simplement creusées sur les côtés du museau, ne pénètrent point dans la bouche*," says M. Cuvier. Neither do these animals respire air in the manner of serpents, for they are both destitute of ribs. When also the proteus takes air into the mouth, it escapes rapidly through the branchial apertures: nor is there any ground for believing that any portion of it enters the very narrow chink of the glottis to pass into its cavity, and from thence through the two membranous canals into the air-bladders. No muscular structure suited to produce such effects exists, and the fine membranous canals, subject to compression every instant from the stomach, altogether unfit them for performing the office of air-tubes or bronchi. In all reptiles that respire air, the structure of the organs is such as to permit free inspiration and expiration, however different the form may be; but in the proteus, the want of ribs and diaphragm, the fact that the nostrils do not open into the mouth, the extreme narrowness of the aperture termed glottis, and the narrowness, length, and compressibility of the

air-tubes, all shew, that in this animal none of those arrangements exist, which nature has instituted with such great solicitude and skill in other reptiles, to carry on with ease and certainty the respiratory function. But it is needless to multiply arguments, to prove that the air-bladders of these animals in nowise perform the office of lungs, since it has been already shewn that, when taken out of the water, they die just as fishes do.

M. Cuvier justly observes, that those animals can alone be deemed truly amphibious, " qui respirent, à la fois, l'air élastique en nature, et celui qui contient l'eau :" and he then goes on to state, that the *sirena lacertina* respires through its whole life by lungs and by gills, and is therefore a permanently amphibious animal; but that the larvæ of other reptiles make use of these two different organs only for a short period, and are therefore only temporarily amphibious. With all due respect, however, to so great a zoologist, we, say the authors, are of opinion, that before pronouncing the siren to be permanently amphibious, it would have been proper to have made upon it, or upon animals which resemble it, experiments similar to those we have made on the proteus. If, in his researches with regard to ambiguous reptiles, he had not contented himself with examining only their skeletons, but had examined also the *larvæ* of the salamander, while yet alive, we are certain that his investigations would have conducted him to opinions entirely opposite to those which he has been led to form.

In our investigations on this point, we have directed our attention to the above mentioned larvæ, to observe particularly the changes which occur in their intimate structure, when they are transformed into *perfect animals* *. Between the siren and these larvæ there is the greatest resemblance, not only in regard to the structure of the branchial arches, but also to the nostrils; for, in the siren, as well as in these larvæ, the nostrils do not

* The investigation here referred to, is contained in a memoir, entitled, " Descrizione Anatomica degli organi della circolazione delle Larve delle Salamandre Aquatiche, fatta dal Dott. Mauro Rusconi," Pavia, 1817. The substance of this memoir, we may, on a future occasion, communicate, from a belief that few questions, either in a zoological or physiological view, possess greater interest, or are at present less clearly understood, than the structure and transformation of these supposed amphibious reptiles.—TRANSL.

open into the mouth. This circumstance prompted us to examine the condition of the bones of the face in these larvæ, and we have thereby satisfied ourselves that the larva of the salamander is unable to breathe by lungs, until the maxillary bones, the zygomatic arches, and the palatine bones are sufficiently developed to form the canal of the nostrils, in such a manner that its posterior extremity may open into the mouth. Before this canal is so formed, these larvæ are unable to respire atmospheric air, and, if taken out of the water, they then soon die; and, therefore, guided by analogy, we incline to the belief, that, to the siren, whose nostrils "ne pénètrent point dans la bouche," the same things ought to happen. Moreover, as its lungs are similar in all respects to those of the salamander, and are furnished with a true glottis, we are farther of opinion, that the siren is the larva of some reptile, the genus of which is as yet unknown, and which will differ from its larva in not possessing gills, and in having a trunk somewhat longer.

To return to the proteus.—We consider that it is not an amphibious animal, having a double circulation, as some have maintained, but a *perfect reptile*, different entirely from all others. It is a reptile, in respect to its having a single circulation, and a fish, in regard to its mode of respiration,—in other words, it is a reptile which respires air mixed with water, while others respire atmospheric air: so that, were it allowable to revive the old idea of a chain of beings, the proteus might be regarded as the link which would connect reptiles with fishes.

From the facts and circumstances above stated, it appears, that the proteus is an animal, which, like fishes, is capable of respiring only in water. Its branchial circulation, however, is only a fraction of the greater circulation, whence it follows, that, in respiration, it consumes less oxygen than fishes do; and, consequently, a smaller quantity of blood in a given time is changed in the gills of the proteus, than, in like circumstances, is changed in the gills of fishes. From this circumstance, as appears to us, continue the authors, arise the inertness, the slow growth, the capacity of enduring fasting, the indisposition in the blood to coagulate, and, lastly, the power of living in a stagnant water, where a fish of equal size would die. With regard to the faculty of generating heat, the authors are unable

to speak with confidence: on this and some other points they were unable to satisfy their curiosity, having sacrificed all the protei which they possessed to other researches.

The reader perhaps may expect, that after having thus set aside the common opinion, that the two air-bladders of the proteus perform the function of lungs, we should declare the purpose they are designed to serve. This, however, say the authors, it is difficult to do, as it is to say what is the true and primary use which the air-bladder serves in fishes; but this point, at a future period, they hope to be able to investigate, both in the protei and in fishes.

Such is a condensed account of the labours of Professors Configliachi and Rusconi, regarding the history and structure of this singular animal. Those who may desire more minute information, must consult the work itself, and more particularly the numerous and beautiful figures, designed by Dr Rusconi, and engraved by Anderloni, with which the work is adorned.

D. E.

Explanation of Plates.

Plate VI. Fig. 1. View of the head from below, eight times greater than natural. *aa*, the two branches of the lower jaw; *bb*, processes of the temporal bones to which they unite; *c*, the roof of the palate; *d*, the os hyoides; *eee*, the three branchial arches of the right side; *fg*, the intermediate bones of the first and second arches; *hhh*, the three first vertebræ; *nn*, the branches of the os hyoides.

Plate VI. Fig. 2. The skeleton of the proteus of its natural size; *a*, the three cartilages, forming the shoulder; *b*, the pelvis.

Plate VI. Fig. 3. The lower half of the trunk of a female proteus laid open. *a*, the alimentary canal shortened and straitened from the action of ardent spirits:—at its termination, it is slit up to shew the common *focus* of the ureters and oviducts, into which two bristles are inserted, the opening from the urinary-bladder is indicated by a single

bristle; *b*, the left *ovarium*, containing minute *ova*, and drawn to one side to display the kidney underneath; *c*, a portion of the oviduct straitened by the action of the spirits; *d*, the left kidney; *e*, the ureter running along its margin, and terminating with the oviduct in the *rectum*; *f*, a portion of the left air-bladder, in this instance remarkably enlarged; the corresponding one of the right side was very small.

Plate VI. Fig. 4. The cranium laid open, to shew the cerebral mass and certain nerves springing from it; *aa*, the two hemispheres of the cerebrum; *b*, the cerebellum; *c*, the medulla oblongata; *d*, the right olfactory nerve; *e*, the origin of the fifth pair of nerves; *f*, the vestibule of the organ of hearing laid open, in which the little sac is seen, and the origin of the acoustic nerves; *g*, the facial nerve; *h*, the entrance of the carotid into the cranium, from which springs the opthalmic going to the eye (*n*); *m*, the origin of the par vagum.

Plate VI. Fig. 5. Profile of the head and part of the trunk; *a*, the external aperture of the nostrils surrounded by pores; *b*, the doubling of the inferior lip, which is in part covered by the superior; *c*, the swelling or protuberance produced by the heart.

Plate VII. Fig. 1. A male proteus laid open, to exhibit the relative size and position of the viscera; *a*, the heart, with its pericardium, opened and turned back; *bbb*, the liver drawn aside, to shew the viscera beneath it; *c*, the stomach; *d*, the alimentary canal; *e*, the spleen; *f*, the pancreas; *g*, the testicle of the left side; *h*, a part of the left kidney; *i*, the urinary-bladder; *k*, the left air-bladder, with its tube, opening into the conical cavity above; *l*, the anus or cloaca; *m*, the sinus of the vena cava.

Plate VII. Fig. 2. *a*, the heart reversed and turned upward; *b*, the short conical canal cut longitudinally, which communicates anteriorly with the glottis, and posteriorly with the cavity from which the two tubes, (*cc*) terminating in the air-bladder, proceed.

Plate VII. Fig. 3. Head of the proteus viewed from below, eight times greater than natural, displaying the circulating and respiratory systems; *a*, the heart; *b*, the arterious trunk spring-

ing from it; *c*, its bulb; *dd*, the two primary trunks arising from the bulb, and again subdividing; *e*, the first branch of the primary trunk, or artery corresponding to the common carotid, and which subdivides into two, one branch (*f*) being continued to the first or exterior gill, and the other (*g*) proceeding to the muscles of the os hyoides; *h*, the vein which carries back the florid blood from the gill.

The second branch of the primary trunk (*d*) soon also subdivides, sending off the branch (*i*) to the third gill, and another (*l*) to the middle gill. To these two branchial arteries, the two veins (*mm*) which carry back florid blood, correspond. The principal trunk of this second branch, after receiving this florid blood, sends off the artery (*n*), which, descending along the air-tube, supplies the air-bladder and generative organs in each sex; it then curves upward, and from its curvature gives off the vertebral artery (*o*), which, after sending some twigs to the occiput, enters the vertebral canal, and descends along it: it also gives off another branch (*p*) to the temporal bone, and then making another curvature downwards, it becomes a branch (*q*) of the aorta, which, by uniting with its fellow of the opposite side, it contributes to form. The aorta (*r*) gives off the branchial arteries (*ss*), the mammary (*u*) and the vessel *t* going to the stomach; the letter *x* denotes a portion of the vena cava cut off.

Plate VII. Fig. 4. A leaflet of the gill highly magnified, exhibiting the branchial artery (*a*), conveying dark blood to the gill, and the branchial vein (*b*), returning florid blood to the aorta.